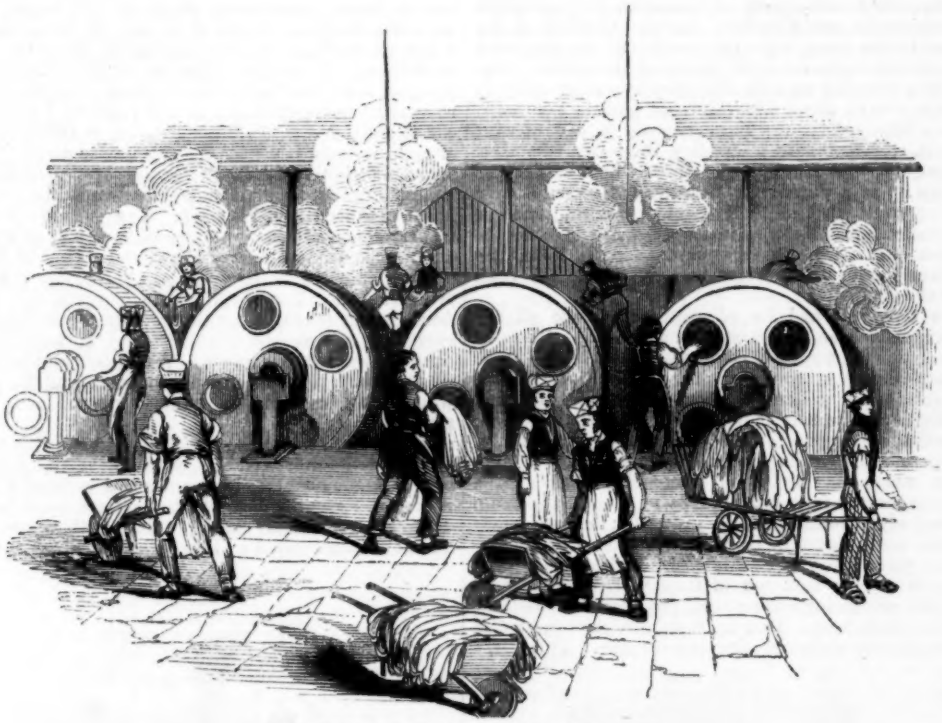
A DAY AT A LANCASHIRE PRINT-WORK.



[Washing by Dash-Wheels (in Bleaching and Dyeing).]

THERE is, perhaps, no other occupation throughout the whole circle of the manufacturing arts requiring so extensive a combination of taste, chemistry, and mechanism as *calico-printing*, or the printing of woven fabrics. The combination of three such opposite agencies may sound oddly; but this is the very circumstance which places the operations in so high a rank; since, although we may meet with as fine taste, as dexterous chemical manipulation, or as exquisite machinery in many other manufactures, we nowhere find all three combined in so remarkable a manner as in this. The eighty or ninety print-works which are now in operation in Lancashire are among the most interesting establishments in the county; and we shall find a 'visit' to one of them both pleasant and instructive.

When calico, muslin, or other cotton fabrics have been spun and woven, as described in our last Supplement, they generally undergo one or more finishing processes before being brought to market. If they are to be sold in the white state, they require *bleaching;* if in a coloured state, they require *dyeing;* if in a decorated or ornamented state, they require *printing:* and hence it arises that there are in Lancashire, as also in the Glasgow district, *bleach-works*, *dye-works*, and *print-works*. As, however, a well-printed piece of cotton requires to be bleached and dyed as well as printed, the print-works have, in most cases, the means for carrying on the bleaching and dyeing, as well as the printing processes; and we have thus facilities for witnessing all three operations in one establishment.

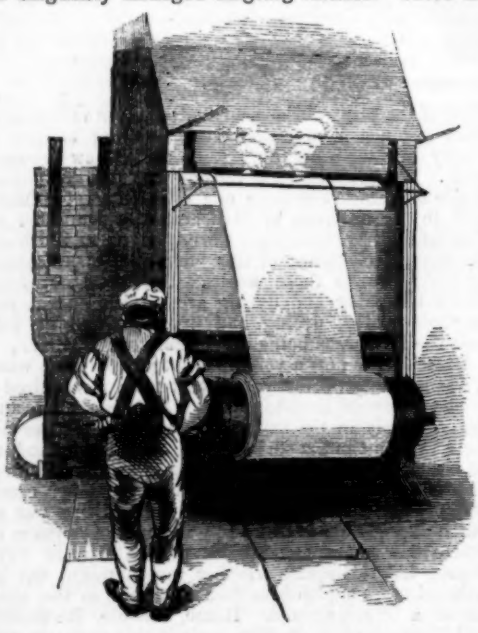
Most of the print-works are situated in the valleys at a short distance from Manchester, in order to have a supply of water from the streams which flow through them. The proprietors of the eminent firm of Thomas Hoyle and Sons, who have one establishment at Mayfield, in the environs of Manchester, and another at Dukinfield, have obligingly permitted us to illustrate the general character of this branch of manufacture by reference to those works. At the Dukinfield works bleaching and dyeing are carried on; at the Mayfield works, dyeing and printing: and we will visit the former, as being preparatory to the latter.

Bleaching is now a very different process from what it was in the last century. At that time it required a period of several months to bleach a piece of cloth, and this, too, only in the summer time: in some cases the cloth was sent in the spring of the year to Holland, to be bleached on the level grassy plains of that country, and returned in the autumn; while in other cases, when bleached in the English fields, there was so much depredation as to lead to an unhappy system of severe laws and general distrust. Chemists were thence led to inquire whether means might not be adopted more expeditious than exposure to the open air of a bleach-ground. Home, Scheele, Berthollet, and Henry, made successive steps in this direction, and paved the way for the introduction of the use of *bleaching-powder*, by Mr. Tennant, about the year 1800. From that date the present most efficient system of bleaching has been followed in the great works of the

north; and we shall be enabled to see how the processes are practically conducted.

The Dukinfield works occupy a very large area of ground on the banks of the Tame, about six miles from Manchester, comprising the *croft* or bleach-house, the dye-house, the reservoirs and water-filters, and subsidiary buildings. The supply of water required in bleaching and dyeing is enormous, and extensive arrangements are necessary for the filtering of the water before using, since the success of the processes very much depends on the purity of the water. The water is pumped up from the river by a steam-engine, at the rate of about fifty thousand gallons per hour, into a large reservoir. This reservoir is bedded with gravel, so disposed in strata that the water can filter through it into a receptacle, from which it may be drawn up in a pure state: in fact, the filtering is very analogous to that of the 'thorough-draining' system in Scotch agriculture, in which the water is collected in tile-drains beneath the porous strata. From this filtering reservoir the water is conveyed to the croft and the dye-house.

In the croft and its adjacent rooms are all the arrangements and apparatus for bleaching. The cotton-cloth (for we shall confine our details chiefly to cotton fabrics) is brought to the works in the 'grey' state, in compact bundles about a foot wide, as much in depth, and as long as the width of the cloth. These bundles are opened, and consigned to the care of women, who sew the pieces, end to end, into a very long strip. A 'piece' of cotton-cloth varies from twenty-four to forty-seven yards in length, and from twenty-eight to forty inches in width; but the kinds woven and printed in England are generally twenty-eight yards long by twenty-eight inches wide. The women sew or tack ten of these pieces end to end, thereby producing a compound piece two hundred and eighty yards long. This long strip is then carried to a singularly arranged singeing-furnace. There is a

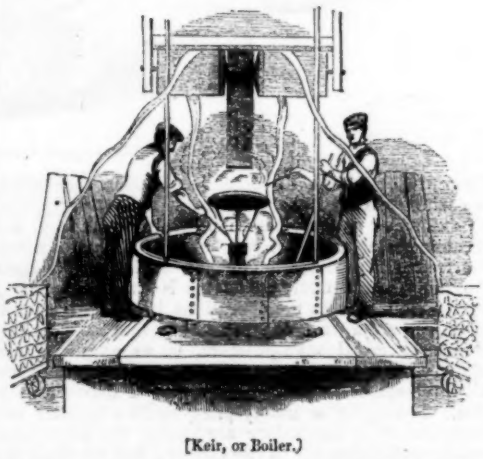


[Singeing.]

heated surface of copper, over which the strip of cotton is drawn rapidly one, two, or three times, by which the light hairy filaments are singed from the surface of the cloth; and the cotton passes round a wet roller to cool from the effects of the singeing.

Matters are then ready for the bleaching process. The *croft* (so named probably because it renders the same service as the croft or bleaching-ground under the old system) is a large and busily-occupied stone-floored building, filled with coppers and vessels of various kinds, abundantly supplied with water, and not often free from clouds of steam. Here successive washings, boilings, and steepings bring the cotton to a white state. In the first place the singed cloth, which has acquired a kind of nankeen colour, is further sewn up, until five hundred pieces are connected together, end to end; that is, there are $500 \times 28 = 14{,}000$ yards, or eight miles of cloth in one continuous piece. This enormous piece passes into a *washing-engine*, to cleanse it from the 'dressing' or mucilage which the weaver had introduced into his warp. The engine contains an abundant and constantly renewing supply of water; and the cloth is wound spirally round a kind of beam above it, hanging in the water in a succession of bends or curvatures. The cloth travels onwards, and in so doing passes twenty times through the water beneath, every part of it ascending and descending twenty times before it leaves the machine. About two hundred and fifty yards are thus washed per minute; and the paste which is washed from the cloth is carried away by a pipe to the river.

As the cloth leaves the washing-machine, it is taken by one or two men, and folded backward and forward till the whole connected piece forms a cube of five or six feet. From this heap it is again removed to undergo the process of 'liming.' The cloth passes into a kind of boiler called a 'keir,' where it is exposed for



[Keir, or Boiler.]

eight or ten hours to the action of a solution of lime, forty pounds of lime being used for the eight miles of cloth. In this keir the hot liquor is brought up a central tube in such a manner, that, being echoed or reflected from a surface above, it falls down on the cloth in a profuse shower, thus acting equally on the whole of the cloth. The cloth is next subjected to a second washing, to remove the lime which may be retained by its fibres. Then ensues the process of 'grey souring,' in which the cloth passes through a machine similar to the washing-machine, but containing very dilute sulphuric acid, instead of water; and after this there is a third washing in the machine, to remove all the adherent acid. After this comes the 'first ashing.' Twenty-four miles of cloth (the real extent of the operations will be better appreciated thus than by

speaking of 1500 pieces) are put into a keir, or cast-iron boiler, and exposed for sixteen hours to the action of a boiling-hot solution of soda: this constitutes the 'ashing.' Then, for a fourth time, the cloth is washed, preparatory to the process oddly named 'chemicking.' Why bleaching-powder should be called 'chemick,' and the process of applying it 'chemicking,' we do not know, unless on account of its being the most important chemical agent in bleaching: but such is the language of the bleachery. A weak solution of bleaching-powder, or chloride of lime, is put into a machine something like the washing-machine, and the cloth is passed through it. After lying wet in a heap for six or eight hours, to allow the 'chemick' to act on the fibres, the cloth goes through the process of 'second souring' in weak sulphuric acid, somewhat as before. It is then washed for a fifth time in the machine; to which succeeds the 'second ashing;' then a sixth washing; then a 'second chemicking;' then a 'third souring;' and then a seventh washing. It will thus be seen that there is a succession of processes following in a certain order; the three agents, sulphuric acid, soda, and bleaching-powder being separately applied, each more than once, and the cloth being washed in clean water after every such application. So powerful is the bleaching-agent, that 7 lb. of chloride of lime are said to suffice for the bleaching of 500 pieces of cloth. The machines here described are a late improvement; for until recently the cloth was dipped in tanks to be 'soured' and 'chemicked,' and thence hauled up by poles.

After a process of 'hot-watering' and squeezing, the cloth leaves the bustling and well-filled croft, and passes up into an upper room, where it is formed into a pile on a wheel carriage, and wheeled to a long table or bench. Boys and girls then take the cloth in hand, and rip or pick the pieces asunder, so that each piece of 28 yards becomes again separated from the others. Each piece is folded into a flat square mass, and men beat these masses against the edge of a stone in a peculiar manner, for the purpose of removing creases from the cloth. The cloth is then hung up on wooden bars in a drying-room, which is heated to a high temperature by steam-pipes near the floor. Finally, the bleached cloth, which now presents a whiteness of the utmost purity, is brought into the warehouse, sorted, and tied up into parcels of ten pieces each.

Such is a brief sketch of the process of bleaching; and whether we notice it in connection with dyeing and printing, as in the present case, or take the instance of a bleachery independent of them (of which there are many in Lancashire), the preceding details will equally serve to convey a general idea of this important process.

Let us next visit the *dye-house*. The five thousand miles of cloth which are bleached in a year in the 'croft' are next dyed before they are printed, or else printed before they are dyed, according to circumstances; and the dyeing is in some cases effected here, at Dukinfield, and in others at the Mayfield establishment. The dye-house at Dukinfield is, we believe, deemed one of the finest in the kingdom. It is more than a hundred feet square, and is provided with a very complete system of drainage, to carry off the vast quantity of soiled water which every day's operations render useless. It is a low-roofed building provided with skylights, which can be opened when necessary. The chances are, when a stranger first visits the building, that he will be totally unable to see the machines, the workmen, or the processes within, on account of the dense atmosphere of steam from the various coppers and boilers; but upon becoming a little used to this source of discomfort, he sees that there are vessels of various kinds ranged in rows from end to end of the building. These vessels we may briefly describe thus:—

The 'dash-wheel,' of which there are several, is a hollow circular wheel, about six feet in diameter and two feet deep, having four compartments within, and four circular openings in one face, one to each compartment. Water is admitted to the interior of the wheel by a pipe close to or concentric with the axis on which the wheel rotates. Cloth is put into each of the compartments, and water being also admitted, the wheel is made to rotate rapidly, and thus to wash the cloth by violent agitation. Another kind of vessel, of which the varieties are more numerous than any other vessels in the dye-house, is the 'beck,' or tank, having over it a kind of frame-work rotated by a winch. In all such machines, whether called 'dye-becks,' 'soap-becks,' or others, the cloth is wound or wrapped on the frame, so as to dip into liquor contained in the beck; and the rotation of the frame by means of a winch causes every part of the cloth to dip successively into the liquor. This is a very common method of saturating cloth with the various liquids employed in dyeing; the liquids being in most cases heated by steam. 'Cisterns' of various kinds are employed to steep the goods, without the aid of the winch apparatus above. There is also a beautiful machine, the operation of which is to drive out nearly all the water after steeping in any of the liquors. The machine consists of a double vessel, the inner one of which is perforated: the wet cloth being put into the inner vessel, and rotated with a velocity of nearly one thousand revolutions in a minute, the centrifugal force thus generated drives the cloth in close contact with the perforated surface, and forces all the water through the perforations, leaving the cloth nearly dry.

The spot where this establishment is situated, viz. Dukinfield, is one of those to which we alluded in the last Supplement as having sprung up into importance solely through the agency of the cotton-manufacture. Cotton-factories are to be seen at a little distance from it on either side, comprised within the limits of Staley Bridge, Ashton, Dukinfield, and Hyde; and the Mersey, or, as it is here called, the Tame, winds past many a bleach-ground and dye-work in its progress towards the sea.

We will now follow the bleached cloth to the establishment at Mayfield, where it is to undergo the beautiful and important process of printing. Mayfield was at one time really a field, before Manchester made such giant strides on every side; but it is now part of Manchester, in the same way as Mayfair is part of London. The works at Mayfield have been gradually increasing in extent for sixty years, and now appear more like a small town than a single establishment, for there are so many open courts and small lanes and passages, so many distinct and isolated buildings, and the whole cover so large an area of ground, that a visitor is apt to lose sight of the connection between them, and to forget that they form, in fact, but one great workshop. There are several distinct departments, which, noticed separately, will serve to convey a notion of the general arrangement of a large print-work; such as the mechanical department, the chemical department, the reservoirs, the designing or artistic department, the printing department, the dye-house, and the finishing.

Many of the printing-machines, the mixing-machines, and other pieces of mechanism incidental to dyeing and drying, require frequent adjustment and repair, as well as a constant and efficient moving-power. Hence steam-engines, engine-houses, millwrights' shops, smiths' shops, and other analogous arrangements, are provided, as in most large establishments in the manufacturing districts.

The chemical department is, however, infinitely more important, or rather, it is more characteristic of a print-work. Perhaps there is no one in any occupation or station of life more conversant with practical chemistry than a first-rate calico-printer. He must study not only the chemical effects of one drug upon another, but the degree in which the vegetable fibres of the cloth will retain those drugs and combine with them; and in endeavouring to imitate the colours of a selected design, he must choose such colouring-agents as will impart to cloth the same tints as the design exhibits on paper. He has to determine also, by oft-repeated experiments, what combinations will make 'fast' colours, since the reputation of the firm greatly depends upon this. Hence in every large print-work there is either a partner or a manager thoroughly versed in practical chemistry; and the drug or chemical department in such establishments shows the importance attached to this matter. At the Mayfield works there is a laboratory fitted up with all the requisite apparatus, such as retorts, sand-baths, furnaces, &c. for making chemical experiments. The shelves are filled with phials and vessels containing most of the usual acids, alkalis, salts, and metallic oxides to be experimented on: and in an adjoining apartment is a chemical library, containing most of the standard works on the theory and practice of chemistry. The calico-printer must not lag behind in the march of science; he must know all new important facts relating to the chemistry of colours as soon as they are made public, and he must therefore have at command the requisite documents and sources of information. Near the laboratory is the colour-house, a large and lofty workshop in which the colours are prepared. Around are dozens and scores of boxes, barrels, jars, and bottles, containing the crude drugs as brought from the manufacturers; and near at hand are the vessels in which and the apparatus by which these drugs are brought into a state fit for use. Copper vessels heated by steam, like sugar-pans, mixing barrels, crushing and grinding apparatus, &c. form some portion of these arrangements.

The reservoirs for containing and filtering the water are similar to those at Dukinfield, and cover a considerable area of ground, almost close to the viaduct of the Manchester and Birmingham Railway: indeed we believe the railway was carried through part of the ground of the works. The reservoirs are emptied from time to time, in order that the layer of gravel at the bottom may be renewed, and a clean stratum laid down, as an efficient filtering medium. A very extensive system of pipes is provided to carry the water to the various vessels where it may be required for use.

Next we come to the highly interesting and important *designing* or *artistic* department, in which all the devices are produced for printing on the cloth. The mode in which these designs are imprinted is very little known, except in the immediate manufacturing districts; nor was the extent of the artistic arrangements at all generally suspected until the Parliamentary Committee on the Copyright of Designs made their Report in 1840. The mode of printing, as we shall presently explain, is a kind of combination of the methods employed in floor-cloth printing, paper-staining, and common press-work, as also machine-printing and colour-printing; for it combines the principle of all these varieties. But before detailing these, we must speak of the designs themselves.

Every piece of printed calico, muslin, or "mousseline de laine," receives its impress from either a piece of metal or a piece of wood; the wood or metal having on its surface a device copied from a coloured drawing on paper. The drawing of these designs is an extensive branch of employment at Manchester; since a rapid succession of novelties in design is one of the points on which the calico-printer relies for success. No matter how elegant a pattern may be, or how great a favourite it may become with purchasers, it will soon outlive its beauties, and acquire that worst of all characters, *i. e.* being "out of fashion." There must thus at all times be new designs in preparation to replace not only those which have had a good run, but those which may from the first prove unsuccessful; for the public, in its wisdom, will sometimes refuse to countenance a design which the printer may have flattered himself is very elegant; and the printer himself may find that a design which looks well on paper will not turn out favourably on cloth. After a design is sketched, it is examined and studied in various ways before being engraved, since the engraving is a much more expensive operation than the designing; and it generally happens that only a very small proportion of the designs which are made are afterwards engraved for printing. Mr. Salis Schwabe, in his evidence before the Committee, stated that in the year 1838 he had had between two and three thousand patterns designed, of which only about five hundred were selected for engraving. The whole of the patterns, in designing and engraving, cost more than five thousand pounds within the year; and this, it must be remembered, was for the patterns for one house only, and in one year. In such a case as this, after the two or three thousand patterns had been sketched, five hundred were engraved, as deemed likely to pay well; but even of this number the printer cannot tell how many may utterly fail—either from the fickleness of the public taste, or from more attractive patterns being produced about the same time—to have a large sale. Mr. Schwabe stated, in illustration of this point, that of the five hundred engraved, only one hundred were decidedly successful; fifty others had a middling result; and the rest had a less favourable fate. Another witness estimated the number of designers in Manchester at five hundred, and supposed that they might produce, one with another, twenty designs per week each, making half a million in the year. Three witnesses estimated that, taking the number of pieces per annum printed in Lancashire, and the wages paid to designers, that the designing costs from a halfpenny to three farthings per piece of cloth. Some of the designs are intended chiefly for the home market; some, especially gaudy patterns, find a more ready sale in foreign parts; while others are equally favourites both at home and abroad. Some patterns, again, are intended for "furniture prints;" that is, for window-curtains, bed-curtains, chair and sofa covers, &c.; while others, comprising the larger portion, are for "garment-prints," whose name sufficiently indicates the character. Furniture patterns are generally more elaborate than garment patterns, and become more expensive. Without entering upon the various opinions expressed before the Committee, as to the effect of a copyright in improving the quality of designs, we shall simply state, that at the time the Committee was appointed, three months' copyright existed; but in September, 1842, a new act came into operation, by which designs for garment-prints were awarded a copyright of nine months, while those for furniture-prints obtained a copyright of three years; every design being registered in a book kept by a registrar appointed by the Board of Trade.

Some of the manufacturing firms purchase their designs from persons who offer them for sale; but the more eminent houses have an establishment of designers and engravers under their own roof. Such is the case at Mayfield. In the designing-room are persons constantly exercising their taste in developing new designs. Sometimes they attempt a new "pattern;"

sometimes a new "style;" for among calico-printers the term pattern is applied to disposition of forms, while style is applied to disposition of colours. In recesses and on tables in the room are large folio volumes containing specimens of all the patterns ever printed by the firm, as well as specimens of the finest foreign productions. The drawings are each about four inches square, and fully coloured. So numerous are the chances against success, that not more than one pattern in about a hundred is finally worked to a successful result; for probably eighty out of a hundred are rejected while yet on paper, and of the remaining twenty not more than one will stand all the severe tests to which it will be exposed, in respect to beauty of appearance on the cloth, facility of working, fastness of colour, and good fortune with respect to the public taste. Hence arises a necessity for an incessant addition to the stock of new patterns.

When the designs are drawn, they are transferred either to wood or to metal, according to the mode of printing adopted. The wood-blocks measure about twelve inches by seven. They have a smooth surface of sycamore on a substratum of some commoner kind of wood; and the design, after being sketched on the block, is cut as in common wood-engraving; the parts being left prominent which are to constitute and print the pattern. In some patterns, where there are fine lines, the wood would soon be worn away or brought to a defective state by use; and to obviate this, little slips of copper are inserted into delicate grooves cut for them, the copper slips all standing at an equal height, and forming the printing surface. Small pieces of felt are in some places introduced to fill up the interstices between the coppers, so as to imprint a broader patch of colour. One block can only print one colour; and therefore if five or six colours form the design, and all be printed by blocks, there must be five or six blocks, all equal in size, but the raised parts in each block corresponding with depressed parts in all the other blocks. The principle involved is precisely the same as that displayed in Floor-cloth printing, which we illustrated with a wood-cut in p. 343 of the last volume.

Another method, quite of modern introduction, is somewhat analogous to stereotype printing. In the first place a model is formed from the design, comprising so much of it as may be included within a space of five inches long by an inch and a half wide. This model is formed of bits of metal inserted into a ground or block; and a mould is produced by stamping from the model. From the mould, fixed in a block and adjusted in a convenient way, stereotype pieces or copies are produced, in a mixed metal of tin, lead, and bismuth. When a number of these pieces are prepared, their surfaces are brought to a perfect level by means of a file, and they are then firmly fixed down upon a stout and carefully prepared piece of wood.

Down to about the year 1785, all woven goods were printed by the block method; but the slowness of the process led to an invention in which the principle of copper-plate printing was employed instead of that of common or press-printing; that is to say, the device is cut *in* a surface of copper, instead of being left *at* the surface of wood. In the 'roller-room' at Mayfield we see indications of the extent to which this method is employed. This room is filled with hollow rollers or cylinders, the external surfaces of which are engraved with devices. Some of the cylinders are about forty inches long, and others about thirty; but all are about five inches in diameter, and half an inch thick. In preparing these cylinders for engraving, the exterior is first brought to the most rigorous exactness and smoothness of surface. The exact circumference of the cylinder is taken by a piece of paper, and on this paper is copied the design, so adjusted that exactly one repetition, or a complete number of repetitions, of the design, may occupy the entire width of the paper, and consequently the entire circumference of the cylinder. Each cylinder is for one colour only, and therefore the paper receives only that part of the design which is to be printed in one colour. The device is slightly marked on the surface of the copper by transference from a kind of waxed paper; and the cylinder then passes into the hands of the engraver, who cuts it by the usual sorts of tools employed by the copper-plate engraver. A most scrupulous exactness of adjustment is requisite in marking and engraving the different cylinders for one device, in order that each one may imprint a particular colour in the precise spot required.

This was the original mode of engraving the cylinders, but Mr. Perkins's principle of multiplying steel-plates has been most ingeniously applied to these cylinders. Mr. Lockett introduced this method into Manchester about the year 1808, and it is thus carried on. A small soft steel cylinder is provided, about three inches long by one inch in thickness; and this cylinder is engraved with so much of the device as its surface will contain. The cylinder is then hardened, and made to give an impress to a softer cylinder, the device being of course *raised* in the second cylinder instead of *sunk;* the second cylinder is then hardened, as the first had been, and becomes the instrument for impressing on the surface of the large copper cylinder the whole of its device. The small original cylinder is called the *die;* the second is called the *mill;* and this mill is applied successively, by the aid of great pressure, to every part of the copper cylinder. The advantage of this method consists in this:—That as the surface of the steel cylinder is not more than one-fiftieth as large as that of the copper cylinder, the amount of work to be done by the graver is proportionably less; and the engraver is thus enabled to devote his attention to the production of patterns which would be too minute, elaborate, and expensive if cut wholly by hand on the copper cylinder.

For some patterns the rollers are engraved by a kind of aquatint process, and the electrotype process is also about being brought into use for the same purpose: but the two just noticed are the principal modes at present in operation. In the roller-warehouse at Mayfield we saw from three to four thousand of these rollers; and as they weigh on an average a hundred pounds each, the ponderous extent of the whole may be judged.

We must now pay a visit to the printing-shops, the scene of those operations to which the designing and engraving are preparatory. There are 'block-printing rooms,' and 'cylinder-printing rooms;' the operations carried on therein being indicated by these names. But there are a few arrangements to which the cloth is subjected before being printed. In the 'cloth department' the rolls or bundles of cloth are opened, spread out upon a table, and carefully examined, with a view to the removal of any loose threads that may appear on the surface. The cloth is then measured by being passed rapidly over a machine a yard in width; and after this twenty or twenty-five pieces are sewn end to end. It then goes to the 'winding-on-room,' where the cloth is wound uniformly round a thick beam or roller preparatory to the printing; passing, in its progress, over a very curious and ingeniously constructed roller, whose surface is so grooved as to take out all creases from the cloth.

The 'block-printing room' is a very long, busily occupied, and most interesting part of the establishment. It contains about fifty block-printing machines, the whole works containing about a hundred and fifty. The whole of the machines are arranged in a double

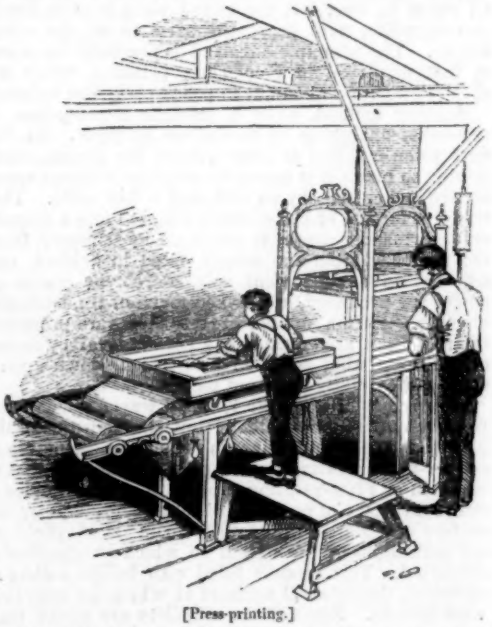
[Measuring-machine.]

row along either side of the room: all are nearly alike; and all are the scene of operations which may be thus briefly described. The cloth roller is so adjusted that the cloth, as it is unwound, may lie on the surface of a table to be printed, and after printing may pass on to another roller; the printer regulating this movement. There is to each machine one man to print, and an attendant boy or girl called the 'tearer.' At the outer end of each machine is a small tub or pot containing the colour to be used, and near it a circular trough or drum supported by a water-bed to give it elasticity. The 'tearer' dips a brush into the vessel of colour, and spreads a layer on the elastic trough. The printer then takes his engraved block, holding it by a handle at the back; presses it down on the trough, whose elasticity allows every part of the raised device on the block to take up a layer of colour; and then prints a portion of the cloth equal to the size of the block.

[Block-printing.]

There are small pins or guide-marks at the corners of the blocks, by which the printer is enabled to adjust each successive impress from the block; and herein consists one of the niceties of block-printing. The printer goes on, step by step, until he has printed the whole of one piece with one colour; and then, at a subsequent operation, he works all over the same piece with a second; then, perhaps, with a third; and so on, according to the number of colours in the design; a new block being taken with every new colour.

A second mode of printing, not long since introduced, is the result of a remarkably ingenious arrangement, whereby all the colours may be printed at once. Let us, for the sake of clearness, suppose that the design contains five colours. In such case five sets of stereotype casts are prepared, in the manner detailed in a former paragraph, each set being for the imprinting of one colour, and the whole five forming the combined pattern. A well-prepared tablet of wood is provided, from two to three feet square, and on this are fixed all the stereotype pieces. All the pieces for one colour are ranged in one row or stripe, about five inches in width; all those for another colour form a second stripe, contiguous to and parallel with the first; all those for a third colour form another parallel stripe; and so on for the fourth and fifth. The length of each stripe is about equal to the breadth of the cloth; and the whole form a compound printing block, divided into five compartments. These blocks are used in a printing-machine something like one of the modern varieties employed in type-printing; but with peculiar adjustments to adapt it to the present object. A man manages the press-work, while a 'tearer' applies the colour. The block is fixed with its face or device downwards to the bottom of a descending beam or frame, capable of receiving a vertical motion; and the cloth being laid out on a table beneath, the block is brought down at intervals upon it, by means of a lever managed by the pressman. But before he does this, the block must receive its coating of colour; and this is effected in a very remarkable manner. The 'tearer'



[Press-printing.]

has five little troughs of colour (supposing, as we have in this case, five to be the number) ranged in a row before him; and he has a long piece of wood so formed as to dip into all these five and to take up a small portion of colour from each, which he dabs upon a flat felt cushion. He then takes a kind of brush so

adjusted as to spread out these five colours in an equal number of patches over the surface of the felt, without combining or smearing one over the other. He next slides the cushion along a kind of railway till it comes underneath the block, which is made to descend upon it, and to imbibe a layer of colour all over its surface, each one of the five rows of device falling upon one particular colour on the cushion, without touching the others. The 'tearer' then draws out the cushion again, and the man guides the block in its descent upon the cloth, which it imprints upon five different places in five different colours. All this is repeated a second time; but before the wetted block actually descends, the cloth has been made to shift about five inches lengthwise, or equal to the width of one row on the block. By this arrangement each colour falls upon a part which had been printed with a different colour in the former descent. At the third descent the cloth is again shifted; at the fourth descent again; and once more at the fifth; so that each portion of the cloth is brought in contact with each of the five divisions of the block, and thus receives five different colours. The utmost exactness is requisite in the arrangement of the five divisions of the device on the block, and in the moving parts of the press, in order that all the colours may conduce to the production of a pattern, without confusion or distortion; but this adjustment once attended to, the action of the machine is very beautiful. There are twenty-four of these press machines.

Next we come to the cylinder-printing, by which such wonderful advance has been made in the capabilities of calico-printing. We will first consider the action of the machine in its simplest form, when only one colour is used. The engraved cylinder is placed horizontally, in the lower part of the machine. The cloth, descending from a beam or roller above, passes over and in close contact with the cylinder. The lower part of the cylinder dips into a long trough containing colour; and as it is kept rotating, every part of the surface of the cylinder of course becomes coated with the colour. Now if the cloth were brought in contact with the cylinder in its present state, it would receive merely a confused mass of colour without device or pattern. The means have to be found, therefore, of cleaning off every particle of colour except from the depressed parts of the engraving; and this is effected in a way which is well calculated to excite surprise in a stranger. A long knife is applied to the cylinder, so exquisitely smooth and regular, and so accurately adjusted to it, as to scrape off every particle of colour from the surface, leaving colour only in the depressed engraving, all the rest being so thoroughly cleansed as to pass over the cloth without soiling it. This important appendage to the machine is called the 'doctor,' a name which has been thus oddly accounted for in Lancashire:—When one of the partners in the firm by whom cylinder-printing was originally applied was making experiments on it, one of the workmen who stood by said, "All this is very well, sir, but how will you remove the superfluous colour from the surface of the cylinder?" The master took up a common knife which was near, and placing it horizontally against the revolving cylinder, at once showed its action in removing the colour, asking the workman, "What do you say to this?" After a little pause the man said, "Ah, sir, you've *doctored* it;" thus giving birth to a name for the piece of apparatus. Others seek for an explanation a little more classical, and would derive the name from *ductor* or *conductor*.

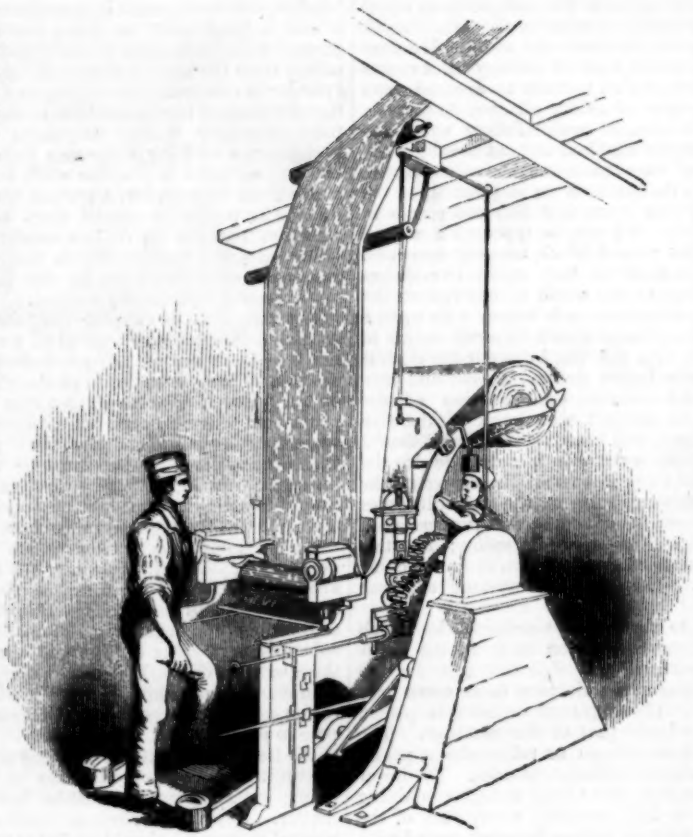
The mode, then, in which cylinder-printing is effected is this. After the cylinder has gathered its coating of colour by rotating with its lower portion in the colour-trough, and has been cleansed by the 'doctor,' the cloth passes in a continuous strip between it and a large roller or drum above, by which it is pressed sufficiently close to the cylinder to imbibe the colour from the sunken device on its surface. As the cylinder is continually revolving, and the cloth as continually passing in contact with it, the printing goes on uninterruptedly without stoppages or breaks, thus presenting a striking difference from block printing. On one occasion, while the cloth was travelling upwards from the cylinder, a portion became disarranged so as to be printed a second time, but in a different direction from the first. This accidental circumstance produced a new pattern which was one of the most successful ever published by the firm in whose establishment the incident occurred.

We have next to suppose that the machine prints several colours at once instead of a single colour. In this case there are as many cylinders as colours, each one scrupulously adjusted to produce its particular part of the pattern. Each cylinder dips into a trough appropriated to itself; each has a 'doctor' to remove the superfluous colour; and the cloth passes in contact with each in turn. What must be the nicety of adjustment to bring all the cylinders to print at the proper places can scarcely be conceived, except by those practically engaged in the process.

Each cylinder machine, of which there are about a dozen at the Mayfield Works, prints a piece of cloth in about a minute and a quarter, or about three quarters of a mile in an hour! Few things are more extraordinary in this department of manufacture than the substitution of *miles* for *yards* in the measurement of the quantity of work done. There are more firms than one in Lancashire, in each of which the length of cotton printed in a year would thread the earth from pole to pole.

We have spoken of the printing process without interrupting the details by allusion to the *dyeing* of the cloth; but a few words must be here offered on this matter. If we had before us one hundred patterns of printed cotton, we should probably find that nearly one hundred different modes of proceeding were necessary in the printing; for not only must the colours be different, but each colour may perhaps require a peculiar groundwork to make it adhere to the cloth. Herein lie the delicacy and complexity of the calico-printer's operations; and hence arises a different chemical formula for almost every different pattern. Sometimes a piece of cloth is partially printed, then dyed, and then printed again; at other times the printing is effected at once; and at others a portion of the printing is to lay on colour which is to be afterwards visible, while the other portion is merely to imprint the cloth with a chemical agent which shall exert some peculiar effect on the colours. This may perhaps be rendered intelligible by alluding to four different kinds of liquids or mixtures, which are printed on the cloth by means of the cylinder, the press, or the block. These four are *colours*, *mordants*, *dischargers*, and *resists*. The name *colours* speaks for itself; it relates to the pigments or pastes which impart colour to the cloth, and includes a very wide range of vegetable and mineral substances. A *mordant* is a liquid mixture which enables the colouring substance to combine permanently with the textile fibre; and this is used when the mordant has a combining affinity with the cloth as well as with the colour, although the two latter, used singly, have no affinity for each other. Thus, if a red colour were imparted to cloth by madder, it would wash out, or not be a 'fast colour;' but if the cloth were previously wetted with an aluminous salt, the madder colour would be permanent. In most cases the mordant is a body of liquid, into which the cloth is immersed; but sometimes it is used in the same way as a paint or

ink by the cylinder machine. *Dischargers*, instead of being intended to fix the colour to the cloth, are used to drive off or discharge the colour after the latter is applied. This kind of chemical agent is used in combination with mordants, thus:—the cloth is wholly saturated with the mordant, but certain parts are also printed with a discharger formed of lemon-juice or some other substance; the result of which is, that when the dye-colour is afterwards applied, it combines with the cloth at the parts where the mordant has been unaffected, but becomes a 'loose' colour at the parts printed with the discharger, so as to be easily washed out from those parts. *Resists* are mixtures which enable the printer to produce white portions of pattern by a process rather different from the discharge-method. The mordant is printed, not dipped, in those parts which are to be coloured in the pattern; while those which are to be kept white are previously printed with a chemical mixture called a *resist* or *resist-paste*. The cloth is then wholly immersed in a dye-vat, but those portions which had been printed with the resist refuse to receive the dye, and hence remain white. It will be seen, therefore, that in 'discharge-work,' as it is called, the white portions are retained by driving out the mordant which would otherwise fix the colour; while in 'resist-work' they are retained by shielding the cloth at those parts from the action of the colour.



[Cylinder-printing.]

The chemical manager of a print-work has to study innumerable points connected with the action of different chemical agents on each other, and on the fibres of the cloth; and hence a description of the precise mode adopted would vary with almost every particular pattern produced. For instance, we have now before us (and should have inserted in this printed sheet, but for certain practical difficulties) a few pieces of different printed cottons, which were thus prepared:—One specimen consists of purple squares separated by white lines: the cloth was first bleached at Dukinfield, and transferred in the bleached state to Mayfield; the squares were printed by cylinder with a mordant of acetate of iron; then stoved; then passed through a hot emulsion of cow-dung; then washed in water; then immersed in phosphate of soda; then dyed with madder, which gave the purple tint to the parts printed with the mordant, but left the rest white; then soaped; then 'chemicked,' to clear or bleach the unmordanted parts; and lastly squeezed, dried, &c. In another specimen, displaying white spots and black flowers on a purple ground, the white and black parts were printed both at once by a two-cylinder machine; the white with lemon-juice to act as a *resist*, and the black with acetate of iron to act as a *mordant*; the purple part was printed by a different cylinder; and the dyeing, clearing, &c. were superadded to these printings. In a third specimen, comprising three different shades of pink, acetate of alumina in three different degrees of strength were employed as the mordants, so as to retain with three different degrees of force the pink dye upon the cloth: two of the shades were printed at once by a double-cylinder machine; and the other was afterwards printed by a third cylinder. A fourth specimen, comprising yellow, green, black, and two shades of red, upon a white ground, went through between thirty and forty processes connected with the printing; it passed twice through cylinder machines, and three times through the hands of the block printers, to apply either the colours themselves, or the mordants or resists by which those colours are effected.

From these few details it will be seen how complex are the labours of the calico-printer. Indeed these do not comprise all the varieties; for in printing 'mousseline de laine,' and some kinds of cotton goods, a particular routine of processes is employed, called 'steam-work,' in which the distinguishing characteristic is the precipitation of the colours on the cloth by the action of steam, in lieu of some of the intermediate processes employed in the other methods.

There are certain finishing processes, such as mangling, starching, drying over steam-heated cylinders, examining, folding, &c., to which the cloth is more or less subjected, according to its quality and the purposes to which it is applied; and many of which would be deemed curious, were not their importance eclipsed by the combination of taste, chemical skill, and mechanical exactness, displayed in the preceding processes. Altogether, this must be acknowledged to be one of the finest of all our manufacturing arts.